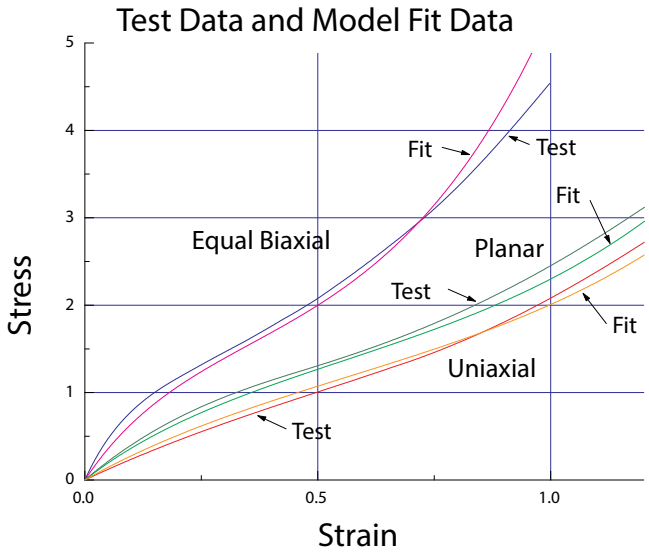
Testing and Analysis

Fitting a Hyperelastic Material Model for a First Time Loading Application

Objective
A material model is needed to describe the behavior of a thick elastomer seal during a factory installation operation.

Introduction
At Axel, we fit material models based on the needs of the application and the capabilities of the finite element software being used. In this case, the material will be compressed and somewhat confined between two mating metal pieces. A hyperelastic model is selected to capture the incompressible material behavior and the complex strain field during the structural loading.



Yeoh Hyperelastic Material Model Fit to Experimental Data

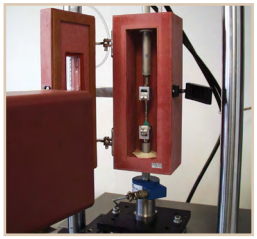
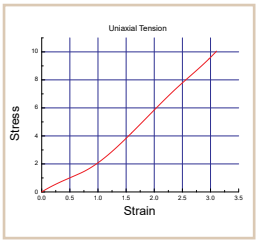
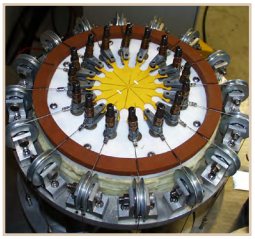
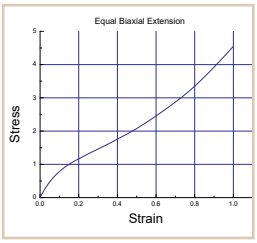
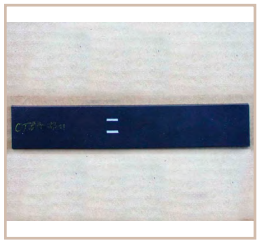
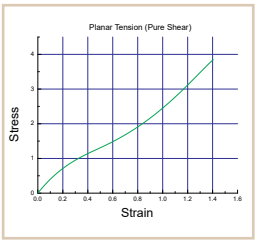
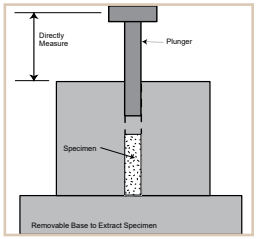
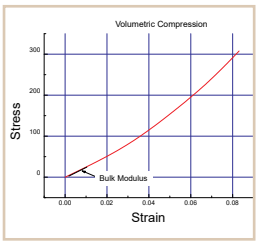
Testing and Modeling Effort
Physical experiments are performed in multiple strain states so that the calibrated hyperelastic model describes the material behavior during complex deformation. Multiple models are reviewed and the simplest math model with the best fit is selected. Models considered include Mooney-Rivlin, Neo-Hookean, Yeoh, Ogden, Gent, and Arruda-Boyce. The experiments run are the three classic experiments: uniaxial tension, planar tension (pure shear), and equal biaxial extension. Because the seal will experience significant confinement, a volumetric experiment is performed to capture the bulk behavior. Uniaxial compression is avoided because of adverse friction effects during the experiment.

The material experiments were performed to high strains yet the application strains were not expected to exceed 50%. As such, the test data was truncated and the material model fitting was restricted to more realistic strains.

The last step is to run single element models to verify that the material model performs as expected in the simulation software under the loading conditions of the experiments. This step must happen. In this case, we ran Abaqus single element simulations in uniaxial tension, planar tension, and equal biaxial extension and compared these results to the experimental data. Any time fitting tools external to the simulation software are used, verification must take place because simple or extreme errors may appear.

Test Plan Summary:
Equal Biaxial Tension Test, Single Loading, 23C
Planar Tension Test, Single Loading, 23C
Uniaxial Tension Test, Single Loading, 23C
Volumetric Compression, 23C

Analysis Tools Summary:
Axel Internal Data Handling Tools
Abaqus CAE
Abaqus for Single Element Verification

	Typical Specimen	Test	Test Data
Uniaxial Tensile			
Equal Biaxial Extension			
Planar Tension			
Volumetric Compression			

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Axel Products provides physical testing services for engineers and analysts. The focus is on the characterization of nonlinear materials such as elastomers and plastics.

Axel Products, Inc.

2255 S Industrial
Ann Arbor MI 48104
Tel: 734 994 8308
Fax: 734 994 8309
info@axelproducts.com

axel
physical testing services